A4161

# SOYBEAN INJURY from dicamba

Investigations of soybean leaf puckering in Wisconsin have often found the injury was caused by dicamba — a plant growth regulator (Group 4) that is prone to drift and commonly used in corn herbicides (i.e., Banvel, Clarity, Distinct, NorthStar, Status, Sterling Blue, Yukon).

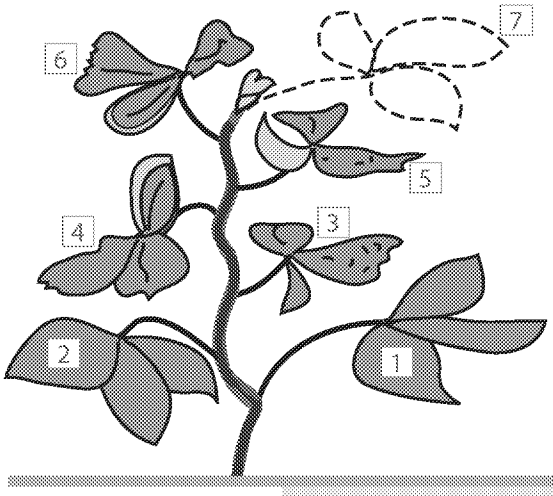
In 2017, dicamba-tolerant (DT) became available to U.S. farmers along with three new restricted use dicamba products for use on DT soybean — Engenia, FeXapan, and Xtendimax. Although this represents a step forward in weed management and reducing injury in some soybean fields, it also potentially increases dicamba use and therefore the likelihood of injury to non-DT soybean and other dicamba-susceptible plants in nearby fields. Other than misapplying dicamba to a non-DT soybean field, there are four common ways that dicamba can reach fields and cause injury:

1. **Spray particle drift**
2. **Vapor drift**
3. **Application during a temperature inversion**
4. **Contaminated spray solution**

Understanding how these work and how to reduce their incidence, along with being able to differentiate between true dicamba injury symptoms and those that mimic dicamba injury will help increase responsible dicamba use.

## Dicamba injury symptoms

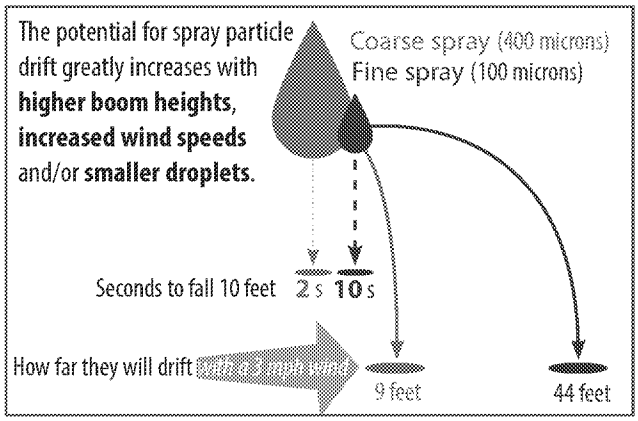
Dicamba is a systemic herbicide absorbed by the roots or foliage and translocated towards the active growing points of the plants; thus symptoms from exposure to low rates appear on the soybean leaves that grow after the exposure occurs. As a result, symptoms are often not noticed for 7–14 days; fully developed leaves on the plant during dicamba exposure typically do not exhibit symptoms. Usually, the next four leaves that develop after exposure are injured the most. Then, most of the final leaves grow to near full size.




*Trifoliate leaves 1–2 had grown before being exposed and are not injured; leaves 3–6 grew after the exposure and are injured; leaves developing after the 6th trifoliate should be close to normal size and shape.*

## 1 Spray particle drift

An important source of dicamba movement to soybean is spray particle drift. Droplet size plays a major role in particle drift. Small droplets take longer to reach the ground, increasing their susceptibility to drift. For example, North Dakota State University Extension demonstrated that a droplet from a fine spray (100 microns) takes 10 seconds to fall 10 feet whereas a droplet from a coarse spray (400 microns) takes only 2 seconds. Add a 3 mph wind, and the fine droplet will drift 44 feet while the coarse droplet will drift only 9 feet. The EPA's Spray Drift Task Force reported that total particle drift from 8004 flat fan nozzles at a 20-inch height with 40 psi and an 8 mph wind was about 0.5% of total volume sprayed at 25 ft, 0.2% at 100 ft, and 0.125% at 200 ft. For most herbicides, this level of drift may not injure susceptible crops, but dicamba drift at any of these levels can cause soybean injury. In these studies, drift was greatly increased with higher boom heights and/or smaller droplet sizes. It is impossible to eliminate tiny drift-prone droplets, but they can be minimized with proper application conditions (e.g., low wind speed) and techniques (e.g., correct nozzle selection, proper boom height and spray pressure, and drift control agents).




Leaf puckering or cupping is a common symptom of dicamba injury.

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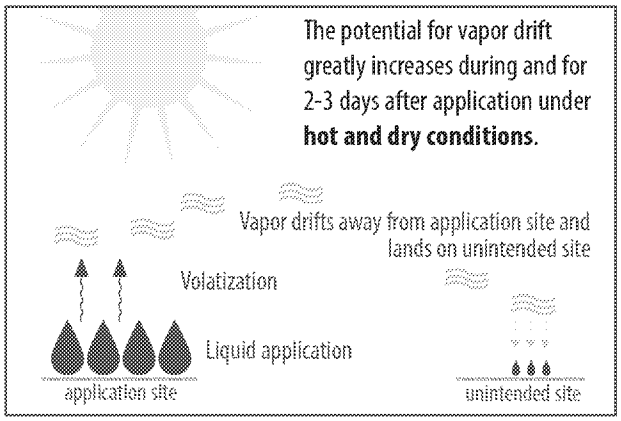
## 2 Vapor drift

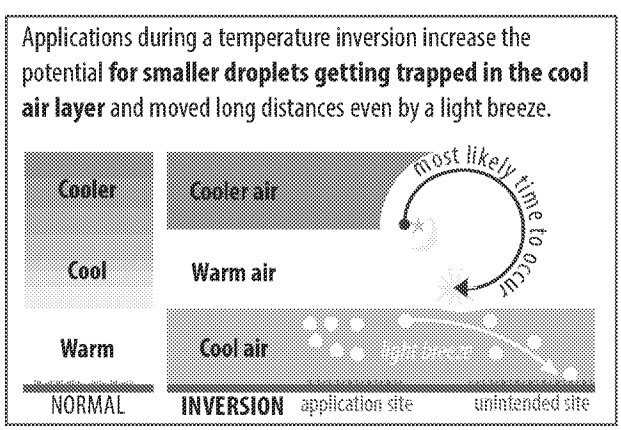
A second source of dicamba movement from treated fields is when dicamba changes to a vapor (volatilization). All dicamba formulations volatilize, but some volatilize more than others. For example, research under lab and field conditions has shown that the diglycolamine salt of dicamba (Clarity formulation) is at least 50% less volatile than the dimethylamine salt of dicamba (Banvel formulation). The restricted use dicamba products labeled for DT-soybeans (Engenia, FeXapan, and Xtendimax) have lower volatility when compared to other dicamba herbicides (i.e., Banvel, Clarity); however, studies have shown that they still can volatilize. Moreover, no AMS (or any product containing ammonium salts) should be added to the tank when the restricted use dicamba products are sprayed on DT soybeans because AMS substantially increases their volatility.

Weather conditions play an important role on dicamba volatilization. For example, volatilization and subsequent vapor drift are more likely to occur at high temperatures (>85 degrees F) and low relative humidity (<40%). However, as little as 0.04 inches of rainfall can dramatically decrease volatilization by washing dicamba off of treated leaves and onto the soil where it is less likely to volatilize. Overall, the potential for dicamba vapor drift is greatest under hot and dry conditions during and for 2–3 days after application.




## 3 Application during a temperature inversion

During normal atmospheric conditions, the air temperature is warmest near the soil surface and cooler at higher altitudes. Cooler air is denser than warmer air; therefore, air is constantly moving vertically during normal conditions. During a temperature inversion, the air temperature near the soil surface is cooler than the air above, preventing vertical air movement. Temperature inversions are common during the summer, and typically start in the evening and may last until the next morning. Signs of temperature inversion include low wind speed (< 3 mph), dust or smoke hanging in the air and slowly moving horizontally, and presence of fog above the crop canopy and dew on top of leaves. Applications during a temperature inversion may lead to small spray droplets getting trapped in the cool air layer and moved long distances across the landscape by a light breeze. Thus, applicators should not spray during temperature inversions. Temperature inversions following an application could also lead to movement of dicamba particles and/or vapor that have not settled across the landscape, but that's difficult to predict and beyond the applicator's control.

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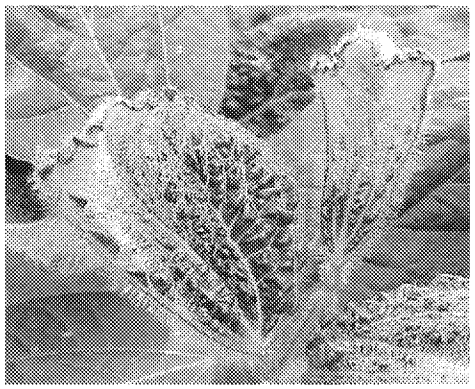
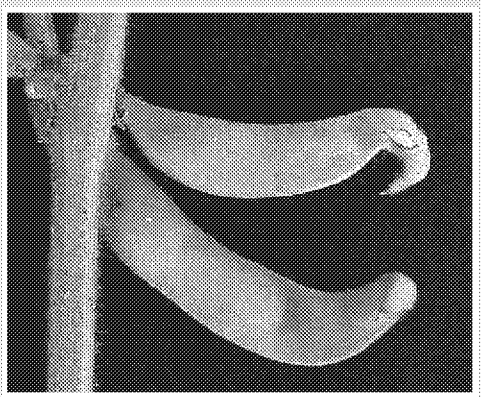
At low doses, injury may appear as a slight crinkle of leaf tips.



In some cases, leaves may be severely puckered with blunt leaf tips. Leaf tips may appear light colored due to dense covering of hairs and unexpanded cells.



If exposed during pod set, yields may be reduced.

## 4 Contaminated spray solution

Another source of dicamba injury is contaminated spray solution. This may occur from contaminated spray tanks, nurse tanks, transfer hoses, measuring containers, screens with residues, or re-used jugs. It has been reported that as little as 0.01% contamination with dicamba can cause minor leaf puckering on soybean. To illustrate how small this amount is, consider a 500 gallon spray tank that applied Clarity at 1 pt/acre; if 6.4 oz (3/4 cup) of this spray solution remained in the tank, sump, or lines, this amount would be sufficient to contaminate the next 500 gallon load at the 0.01% level.

It's important to note that even spray tanks cleaned using common procedures (rather than according to more thorough label directions) can leave measurable concentrations of dicamba. Weed researchers at UW–Madison tested a sprayer for residues after spraying dicamba. The tank was drained, washed with an ammonia-water solution (also flushed through the booms), and re-filled with water. The water from the spray tank and water sprayed out of the boom was sampled and analyzed for dicamba (table 1). The dicamba concentration in the spray tank's water was extremely low, but the concentration may have been sufficient to cause minor injury symptoms. The water from the spray boom contained a higher concentration of dicamba, which might cause moderate soybean injury. This concentration suggests the boom was not adequately cleaned.

Similarly, small amounts of dicamba from the improper use of an old jug to shuttle other herbicides or adjuvants can contaminate spray solutions. The reuse of old herbicide containers in this manner is illegal. Only 0.05 oz of Banvel or Clarity would contaminate a 500-gallon load (calibrated to spray 15 GPA) at the 0.01% level. A non-rinsed jug could certainly retain this small amount of dicamba.

## Soybean yield loss from dicamba injury

Without a doubt, extremely low dicamba concentrations can cause soybean injury symptoms. Minor symptoms, while often causing concern, do not typically result in yield loss. As concentrations increase, injury symptoms and the potential for soybean yield loss increase. The level of yield loss depends on the amount of dicamba that is absorbed by soybean plants and their growth stage. It's impossible to state the exact dicamba concentration that causes yield loss due to soybean's ability to recover from injury, differences among varieties, and variation in growing conditions among years. However, yield loss commonly occurs when severe injury symptoms persist through the growing season.

In general, experiments have shown that soybeans recover from minor to moderate dicamba injury in the vegetative stage without suffering yield loss. However, yield loss is more likely to occur when soybeans are exposed to dicamba after they begin to bloom (R1 growth stage). Typically, soybeans are more frequently exposed

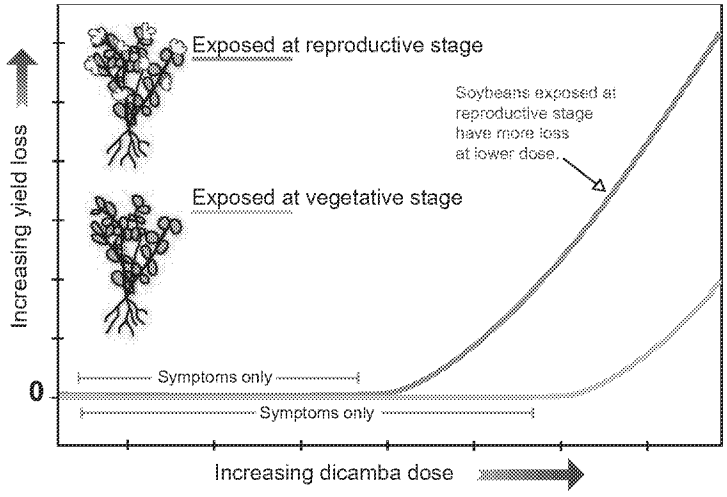


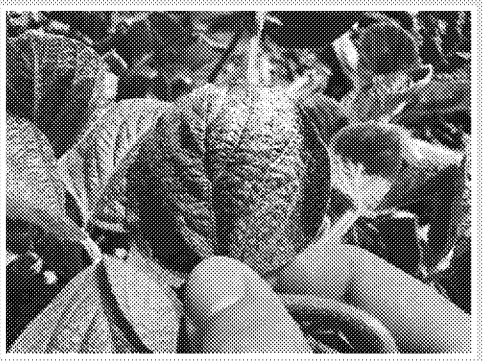

**Table 1.** Dicamba residues detected in water after a sprayer was drained, washed and flushed with an ammonia-water solution, and re-filled with water.

| Water source | Dicamba (ppb) | Percent of use rate* |
|---|---|---|
| Spray tank | 945 | 0.02% |
| Spray boom | 24,800 | 0.63% |

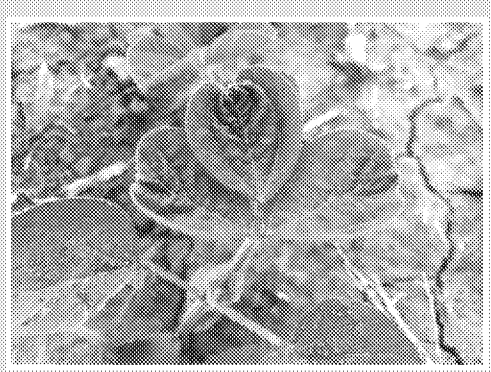
* Based on 1 pt/a Banvel or Clarity applied in 15 GPA water

### Dicamba injury mimics

Other herbicides can cup, pucker, or strap soybean leaves but do not cause the same pattern on the plant as dicamba injury — four or five puckered leaves followed by recovery or leaf injury concentrated toward the leaf tip (see illustration on first page). Also, insect feeding and viruses can also mimic injury symptoms similar to those of dicamba.



Contact soybean herbicides like Cobra or Flexstar (Group 14) can cause the first leaf that expands after spraying to crinkle; the next leaf, however, is not injured. Dicamba does not cause leaf burn.



In cold and wet soil conditions, Group 15 herbicides like Dual II Magnum, Outlook, or Warrant can cause a drawstring appearance, where the leaf tip is pulled in. The following new growth is normal.

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to dicamba in the vegetative stage than in the reproductive stage when dicamba products are used in corn. However, this could be more concerning when DT soybeans are sprayed with dicamba at later growth stages (Engenia, FeXapan, and Xtendimax labels allow for applications up to beginning of flower [R1 stage]) and non-DT soybeans are in the vicinity.

Growers and agronomists should investigate any soybean injury and determine its cause. Leaf samples can be submitted to third-party labs to test for dicamba. However, if dicamba or dicamba-containing products caused the injury, use caution in trying to predict the yield effect. Due to the sensitive nature of soybeans to dicamba, injury symptoms are not reliable indicators of yield loss.

## REDUCE THE RISK OF SOYBEAN INJURY FROM DICAMBA

*Soybean injury from dicamba usually results from mistakes during mixing, tank cleaning, or application; however, even if everything is done according to the label, volatility is difficult to predict and prevent and could lead to injury to sensitive plants. Spending a little extra time during these activities may prevent or reduce the risk of injury. These simple recommendations can reduce the potential for soybean injury from dicamba. Always read and follow the label; the label is the law.*

1. **Clean spray tanks** according to label directions.
2. **Do not re-use old herbicide containers** to shuttle herbicides or adjuvants.
3. **Thoroughly rinse and clean** measuring containers after measuring dicamba.
4. **Do not spray when wind exceeds 10 mph.**
5. **Do not apply when wind is blowing towards** adjacent susceptible plants.
6. **Adjust boom height, spray pressure & select nozzles** to minimize spray drift.
7. **Avoid dicamba applications during hot and dry weather** to reduce volatilization.

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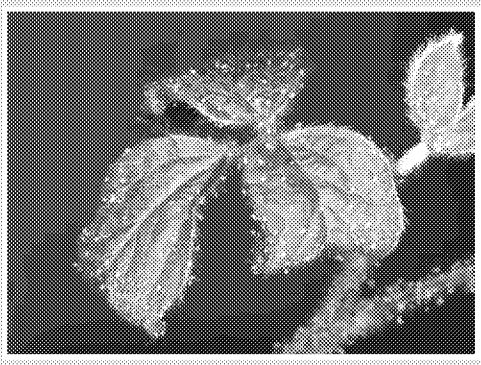
Leaf cupping can be caused by carryover of clopyralid (Group 4), an ingredient in Hornet.



Heavy soybean aphid feeding can cause leaf cupping.

Bean pod mottle, soybean mosaic, and tobacco streak viruses can cause downward cupped soybean leaves.

Bean pod mottle and soybean mosaic viruses can cause a bumpy appearance on leaves. Some viruses also cause a yellow blotchy appearance.